Ambient Temperature Measurements from Radiosondes Flown on Constant-Level Balloons

RALPH D. REYNOLDS AND ROY L. LAMBERTH

Reprinted from JOURNAL OF APPLIED METEOROLOGY, Vol. 5, No. 3, pp. 304–307, June 1966

5

Reprinted from JOURNAL OF APPLIED METEOROLOGY, Vol. 5, No. 3, June 1966, pp. 304-307
American Meteorological Society
Printed in U. S. A.

Ambient Temperature Measurements from Radiosondes Flown on Constant-Level Balloons

RALPH D. REYNOLDS AND ROY L. LAMBERTH
U. S. Army Electronics Research and Development Activity, White Sands Missile Range, N. Mex.

(Manuscript received 15 September 1965, in revised form 27 January 1966)

ABSTRACT

A cause of erroneous temperatures obtained in the earlier phases of a study using standard radiosondes flown on constant-level balloons at White Sands Missile Range is discussed. A simple and inexpensive modification of the radiosondes which produces more accurate ambient temperatures on daylight flights is described.

1. Introduction

The standard radiosonde is designed to measure atmospheric temperature as the instrument ascends on a balloon. Usual ascent rates are from 900 to 1000 ft min^{-1}, and ventilation at these rates is explicit in calculations of thermistor response performed by Badgley (1957) and others. The measurement of true ambient temperature from floating balloons is much more difficult because ventilation is essentially lacking. The use of constant-level balloons as meteorological sensor platforms is accelerating, as is evidenced in the GHOST (Global HOrizontal Sounding Technique) program, and in other projects such as the study of mountain lee waves being made at White Sands Missile Range (WSMR). In this study, radiosondes flown on superpressure balloons produced inaccurate, erratic, and unusable temperatures on the first few flights. This paper describes a simple and inexpensive modification to the radiosonde which was devised and from which more accurate ambient temperatures were obtained.

2. Background

During the spring and winter seasons of 1963 through 1965, a study of mountain lee waves was conducted at WSMR. The basic technique of this study was the tracking by AN/FPS-16 radar and AN/GMD-1 ground equipment of the three-dimensional motion of superpressure balloons with radiosondes attached, as they floated across the range from the west and passed over the San Andres mountains. The temperature records from the first few flights did not yield accurate or even usable results. Instead, the readings were erratic and had numerous heat "spikes" as seen in Fig. 1, which is a typical trace, reproduced from the recorder chart of a flight made on 29 April 1963 at 1400 MST at a pressure height of 250 mb. The ambient temperature during this 10-min interval ranged from −52.0 to −53.0C while the spikes ranged to −35.0C, indicating an error of 18C. Ambient temperature is defined herein as the undisturbed atmospheric temperature outside of any boundary layer. The ambient temperature of −52.0 to −53.0C was established from two regular radiosonde flights made within the same space and time frame. The above temperatures compared favorably with the temperature for the coldest parts

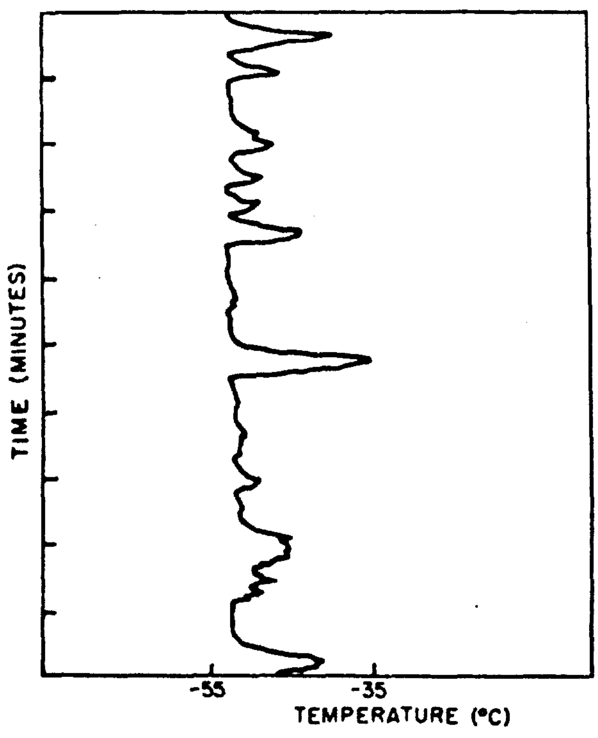

FIG. 1. Radiosonde temperature from a balloon floating at 250 mb on 29 April 1963. The coldest part of the temperature trace was equal to the ambient temperature.

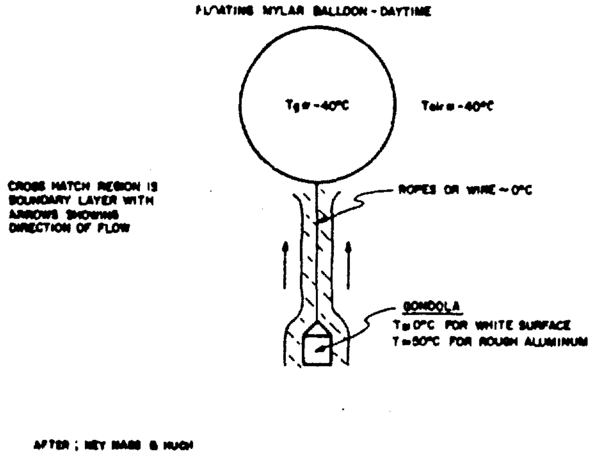

FIG. 2. Floating mylar balloon in daytime. The temperature of the balloon gas (T_g) is equal to the temperature of the ambient air, so no heat boundary exists around the balloon.

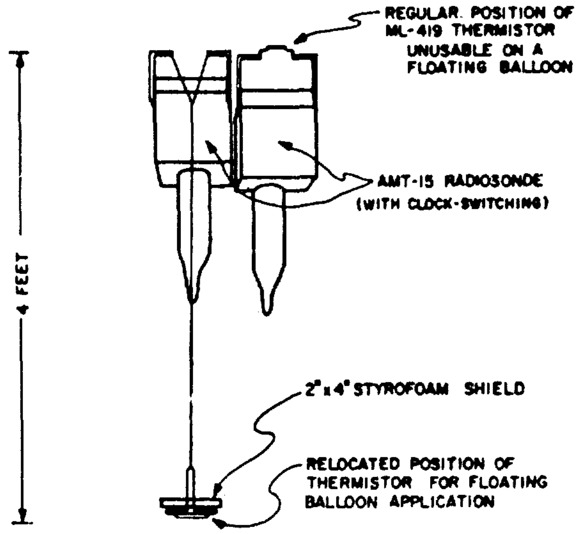

FIG. 3. Modification of the radiosonde for use with a constant-level balloon. The 2 inch × 4 inch styrofoam shield is cut from ½ inch stock.

of the trace shown in Fig. 1. The continuous temperature trace was obtained by removing the baroswitch arm from the AMT-4B radiosonde while later flights used the AMT-15 radiosonde, in which the temperature, humidity and pressure circuits are switched by a clock mechanism, a necessary technique for radiosondes used with constant-level balloons. Initially it was thought that pendulum or bobbing motions might be producing the erratic temperature readings, but calculations showed that the frequency of this periodic motion did not agree with the frequency of the heat spikes. A search of the literature on the use of thermistors as atmospheric sensors produced ample material

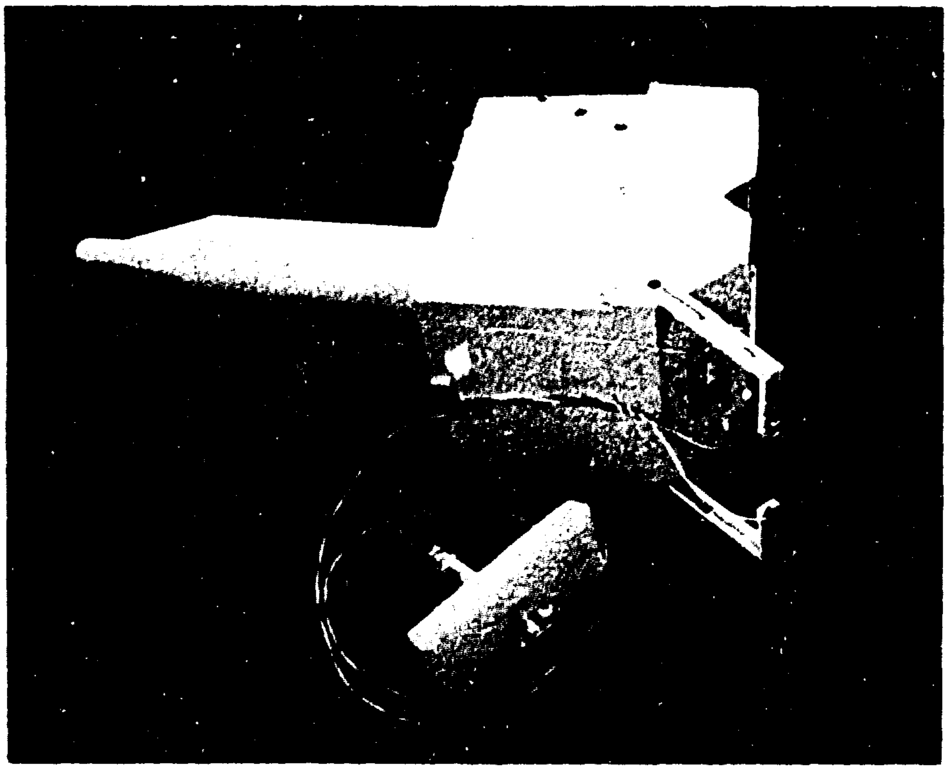

FIG. 4. This close-up shows the dangling thermistor (dangler) attached to an AN/AMT-15 radiosonde. The thermistor support of the dangler is made by taping two regular radiosonde thermistor support arms back-to-back.

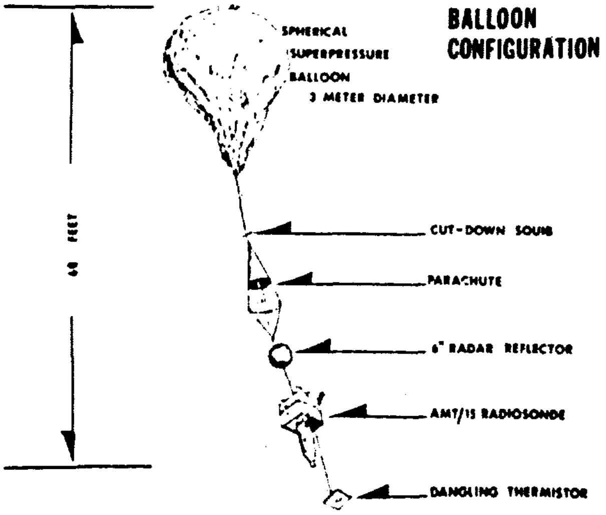

FIG. 5. The balloon train as used in lee wave study at White Sands Missile Range. The size of the balloon varies from 2 to 3 m depending on the float altitude that is desired.

pertinent to rising balloons, but very little regarding floating balloons. However, Ney *et al.* (1961) presented results of a carefully made study of the heating effects of boundary layers in and around floating balloon trains. Their results show that heat from the boundary layer flows upward during the daytime. (See Fig. 2 which is patterned after their diagram.) Their similar diagram for flow at night is not shown since, in the mountain lee wave study, all but one of the flights were made during daylight hours. It was decided to relocate the thermistor below the radiosonde as suggested by Ney *et al.* (1961). Wagner (1965) also treats the same problem.

3. Modification technique and tests

The termistor was relocated four feet below the usual position in the radiosonde by use of brackets and extended leads, as seen in Fig. 3, where the "dangling" thermistor location is compared with the usual position. Fig. 4 shows a close-up of the complete modification. The AMT-15 radiosondes were modified before the baseline check calibrations were made. The modification did not make the baseline check calibration any more difficult or complex, but the radiosonde was a little more difficult to release. Fig. 5 shows the complete balloon train as it was used in the lee wave study.

The first flight which used the modification was made on 13 May 1963 with an AMT-4B radiosonde attached to a balloon which floated at a pressure height of 100 mb. The temperature trace from this flight (Fig. 6) was very stable, with no heat spikes, and varied from −62.4 to −63.7C during the floating period. These temperatures were consistent with those reported from

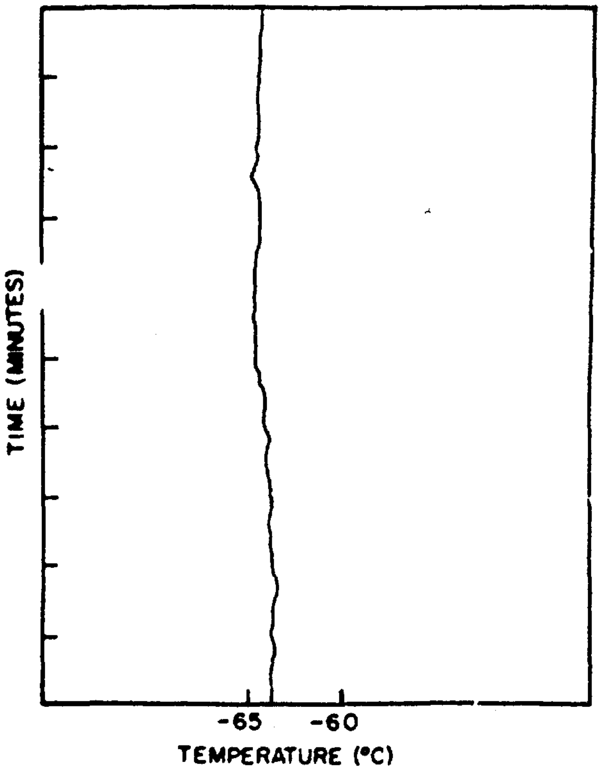

FIG. 6. A temperature trace from a modified radiosonde attached to a balloon floating at 100 mb on 13 May 1963. This temperature trace is from the first dangling thermistor that was flown.

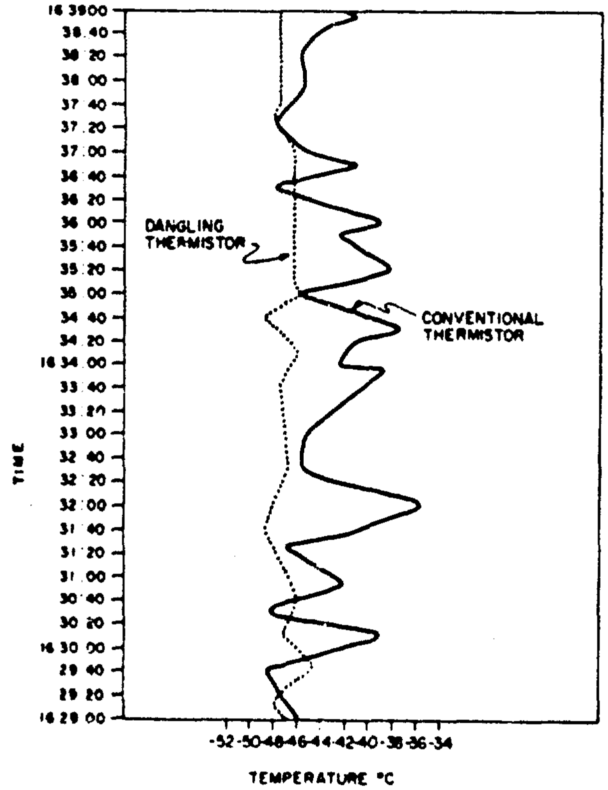

FIG. 7. A comparison of temperature traces from a regularly positioned and a dangling thermistor taken by one radiosonde on 3 June 1964 at 30 mb pressure altitude. The humidity circuit was suitably adapted to a temperature circuit for a dangling thermistor. (Time is in minutes and seconds.)

a regular radiosonde ascent made within two hours and ten miles of the test flight. Subsequent flights for the mountain wave study, using the dangling thermistor technique, also produced satisfactory temperature traces.

A more conclusive test of this technique was made on the afternoon of 3 June 1964 when two thermistors, one in the standard brackets and the other dangling below the instrument, were used simultaneously on a single AMT-15 radiosonde attached to a balloon floating at a pressure height of 30 mb. The second thermistor replaced the humidity sensor in the modified circuit, and the preflight baseline check of the radiosonde produced two sets of values for the temperature evaluator. The results of this test are shown in Fig. 7, reproduced from a section of the recorder record. The actual record showed two consecutive temperature traces, followed by breaks for the reference and/or hypsometer traces which were not reproduced in this figure. Dots connecting the trace segments from the dangling thermistor make the record appear continuous. Solid lines were used in the same way for the trace from the thermistor mounted in the regular position. The heat spikes in this figure are not so large as those in Fig. 1, but reflect errors of more than 11C in the regular thermistor. Significant also are the ranges of temperature within this 10-min interval. The dangling thermistor ranged from −44.5 to −48.5C for a difference of 4.0C, while the regularly mounted thermistor ranged from −36.0 to −48.5C, or 12.5C. For this test also, the temperatures from the dangling thermistor agreed well with those from a standard ascending flight made nearby in space and time.

4. Conclusions

Accurate ambient temperatures were needed from radiosondes flown on constant-level balloons. Research of the problem disclosed that ambient temperatures from floating balloons during the daytime could be obtained by dangling a thermistor below the boundary layer of the balloon train. The simple dangling thermistor technique herein described was found to be accurate within ±1C by comparison with a regular radiosonde sounding taken within essentially the same space and time frame.

This inexpensive modification, which is suitable for use with any American radiosonde currently in use, eliminates the erroneous temperatures resulting from the heat boundary layer of a balloon floating during daylight hours.

REFERENCES

Badgley, F. I., 1957: Response of radiosonde thermistors. *Rev. Sci. Inst.*, 28, 1079–1084.

Jordan, C. L., 1960: Apparent diurnal temperature variations from meteorological observations. *J. Meteor.*, 17, 569–571.

Kochanski, A. B., 1956: Wind, temperature, and their variability to 120,000 feet. Air Weather Service Tech. Rep. TR 105–142.

Ney, E., R. W. Maas and W. F. Huch, 1961: The measurement of atmospheric temperature. *J. Meteor.*, 18, 60–80.

Spaulding, T. B., and S. B. Solot, 1961: Horizontal sounding balloon feasibility study. *GRD Research Notes No. 56*, Air Force Cambridge Research Laboratories, Bedford, Mass.

Staff of Meteorological Systems Branch, 1961: Instructions for Radiosonde Set AN/AMT-15 (XE-2). U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J.

Wagner, W. C., 1965: Temperature measurements from floating balloons. *Proceedings, 1964 AFCRL Scientific Balloon Symposium*, Air Force Cambridge Research Laboratory Report AFCRL-65-486, 157–168.